

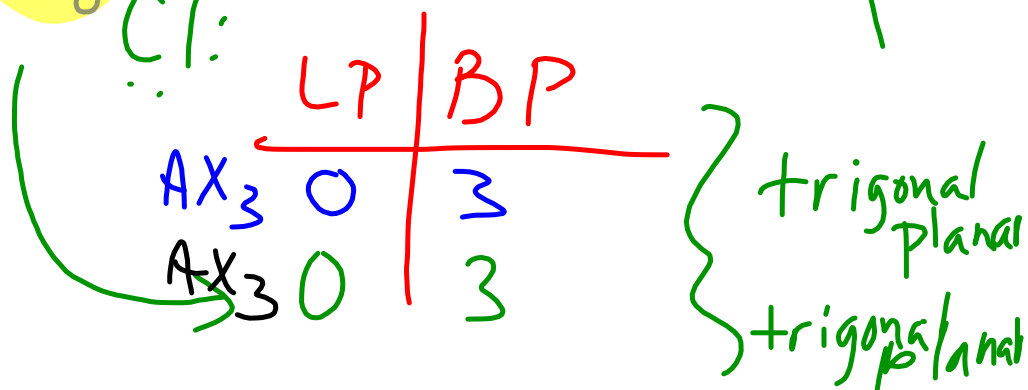
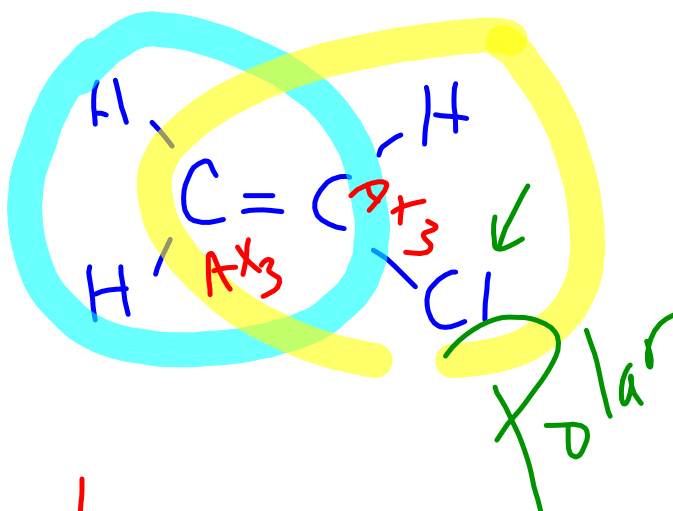
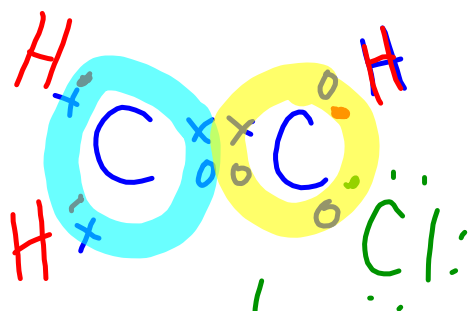
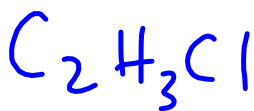
# VSEPR



According to VSEPR theory, the repulsion between electron pairs causes molecular shapes to adjust so that the valence-electron pairs stay as far apart as possible.

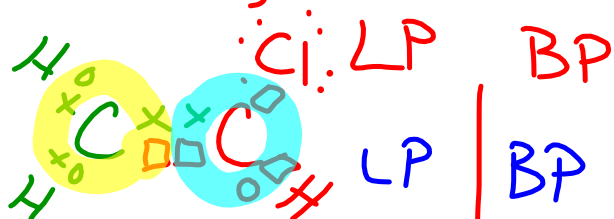
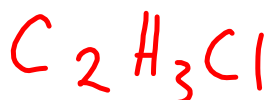
## VSEPR

Shape	Lewis	LP	BP	Structure or	Polar
General Formula	Diagram			shape diagram	or Nonpolar
and name					

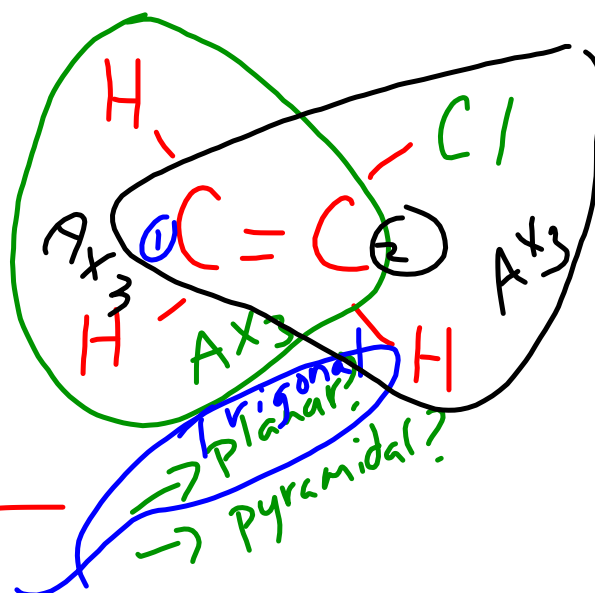


## VSEPR

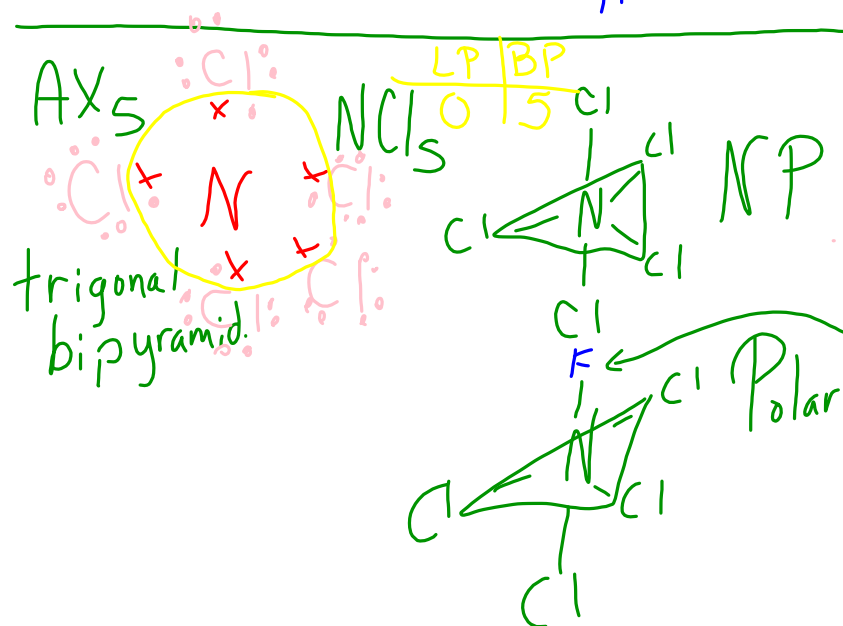
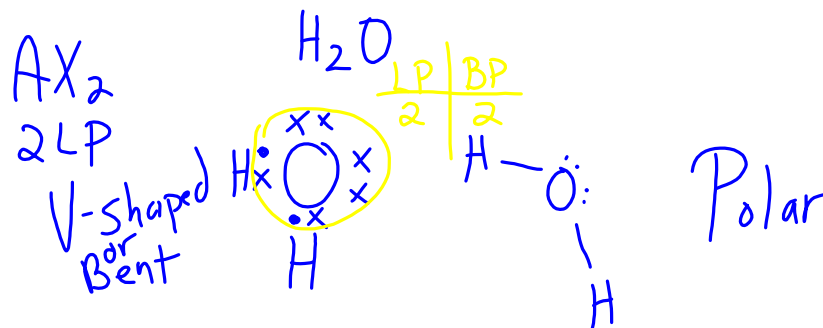
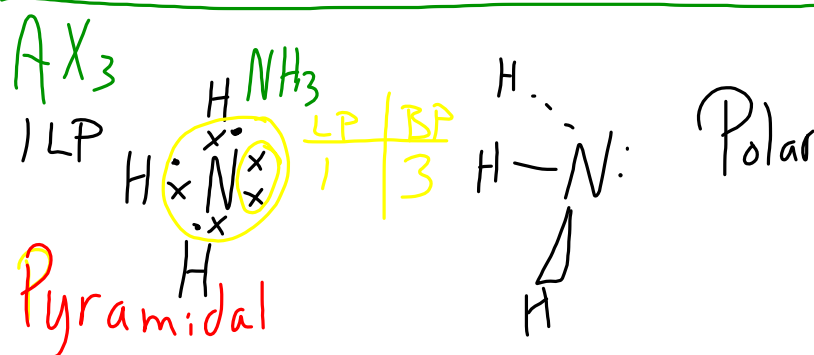
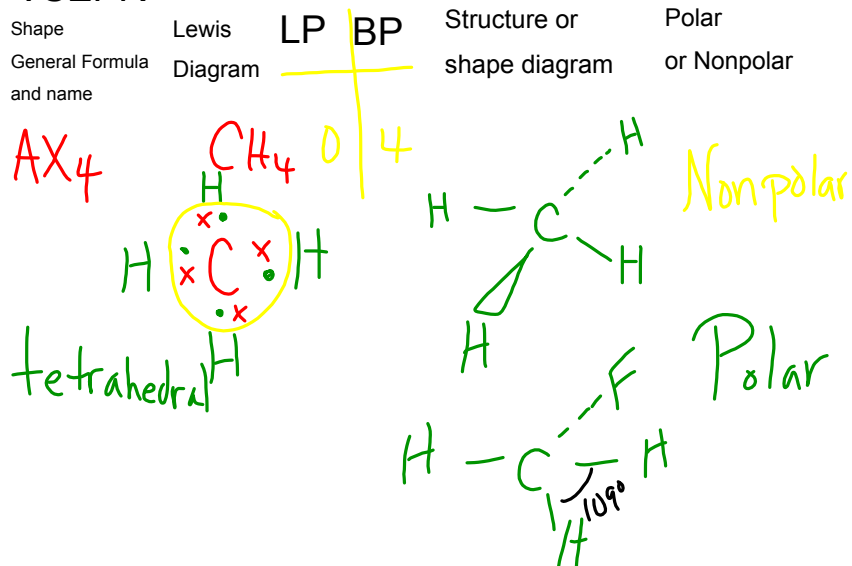
Shape	Lewis	LP	BP	Structure or	Polar
General Formula	Diagram			shape diagram	or Nonpolar
and name					



$C_1 AX_3$	0	3
$C_2 AX_3$	0	3



## VSEPR



# VSEPR

Shape

General Formula  
and name

Lewis

Diagram

LP BP

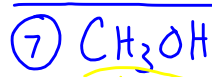
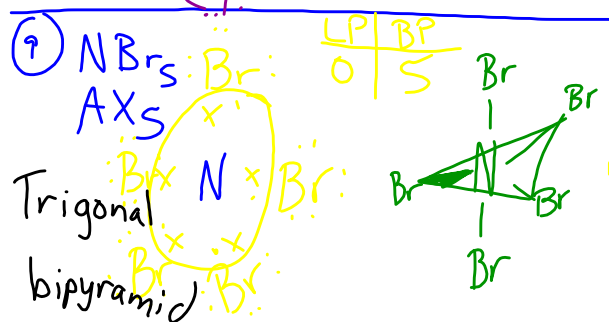
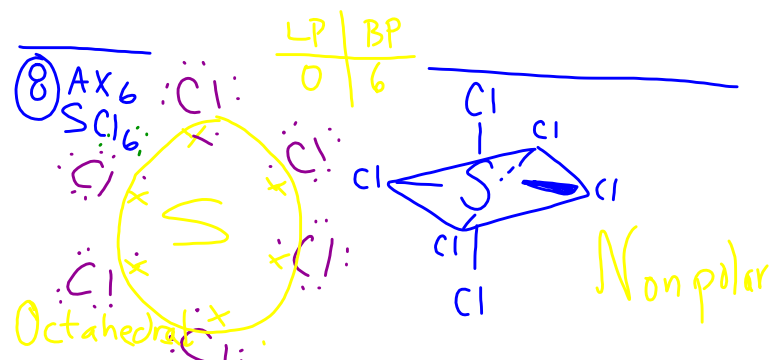
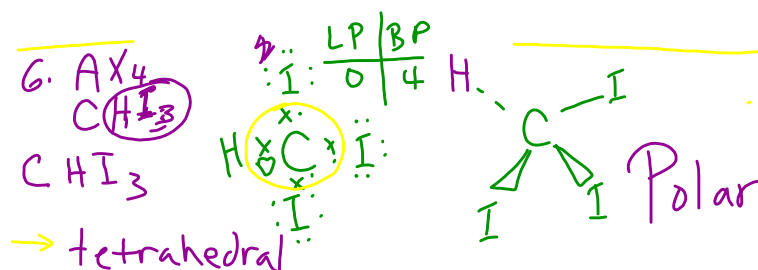
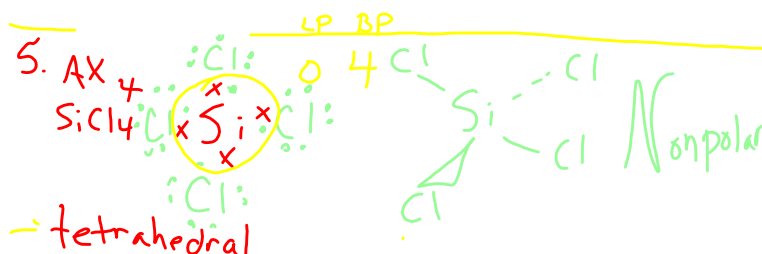
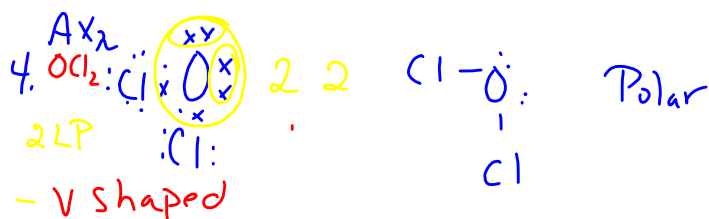
Structure or  
shape diagramPolar  
or Nonpolar

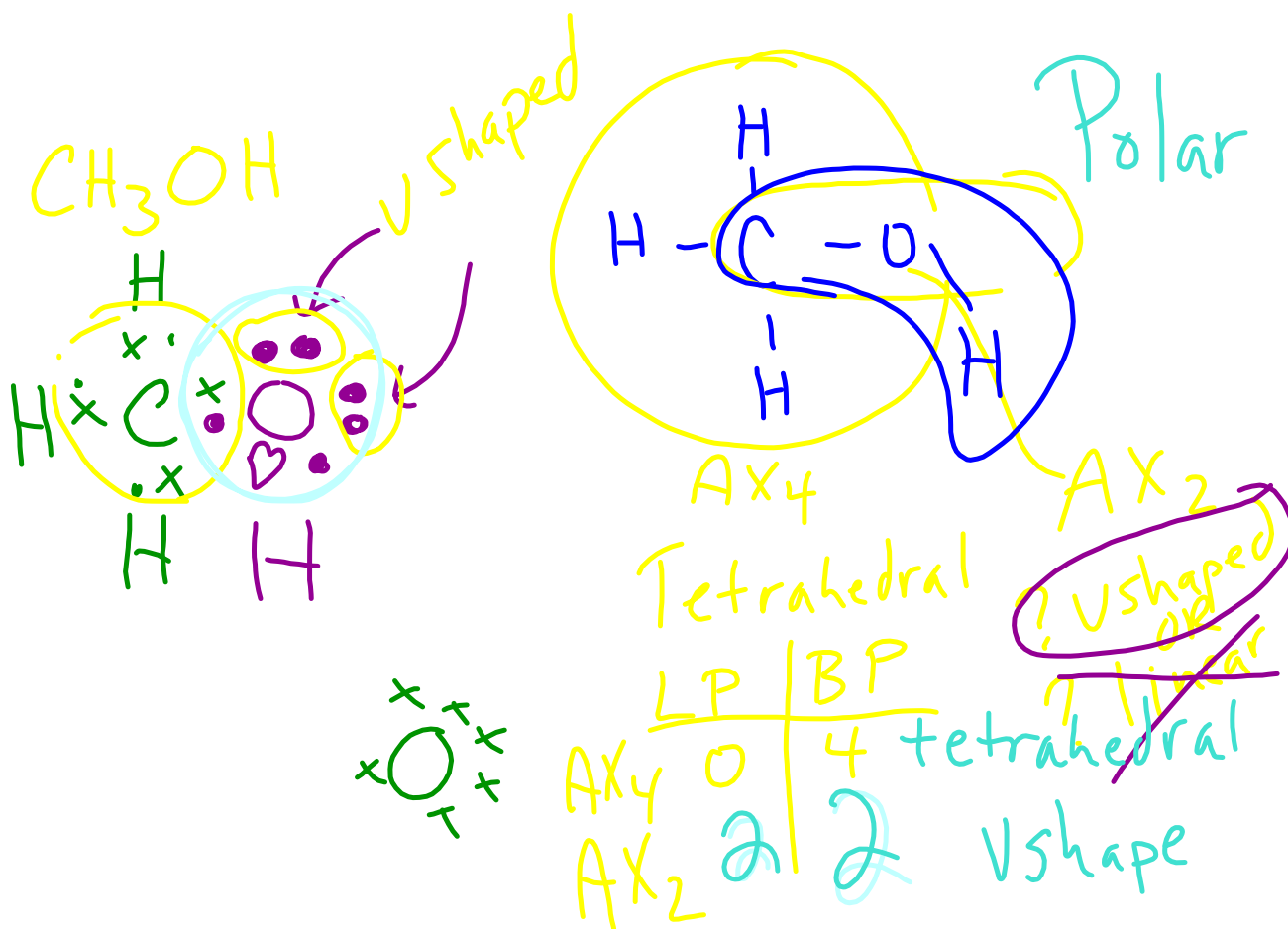
.

## VSEPR

## ANSWERS

Shape	Lewis	LP	BP	Structure or	Polar
General Formula	Diagram			shape diagram	or Nonpolar
and name					

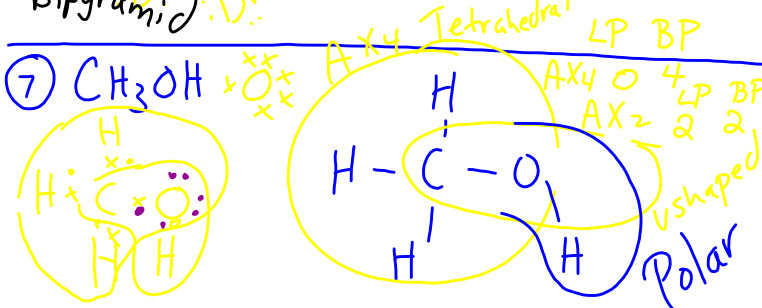
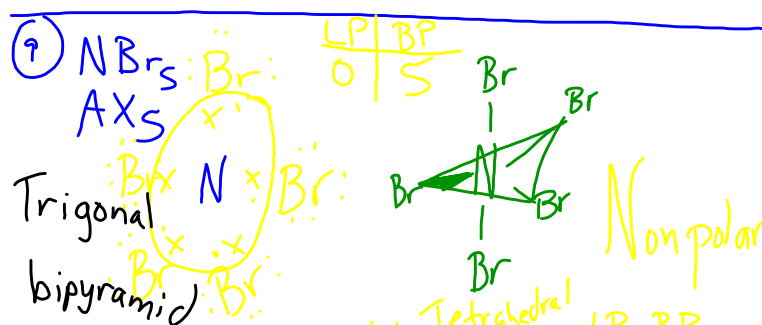
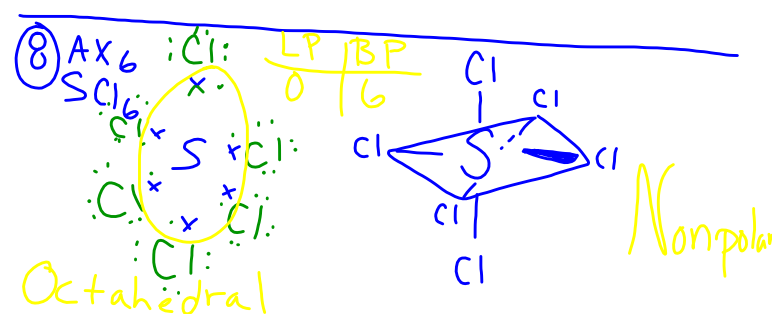
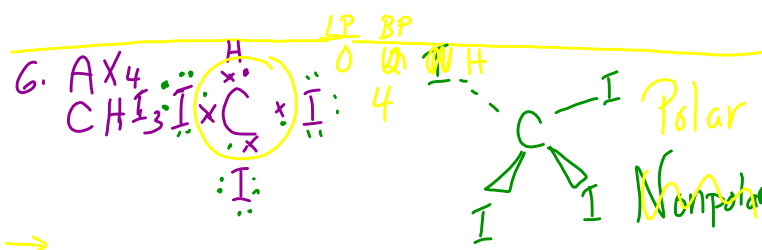
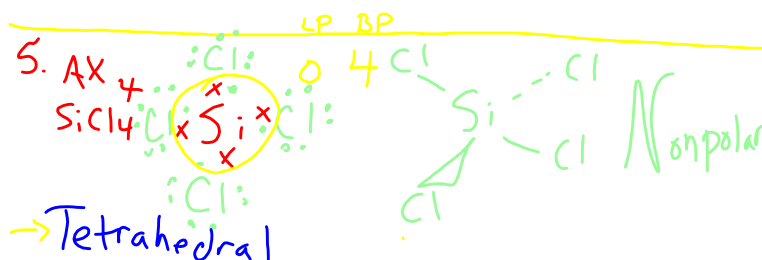
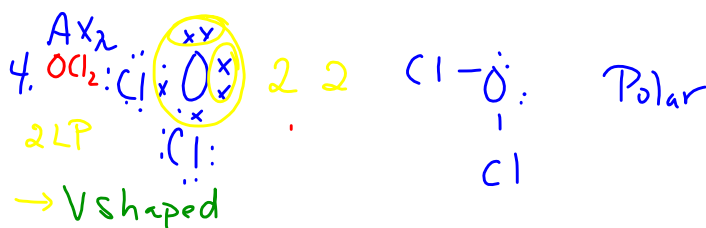




## VSEPR

## ANSWERS

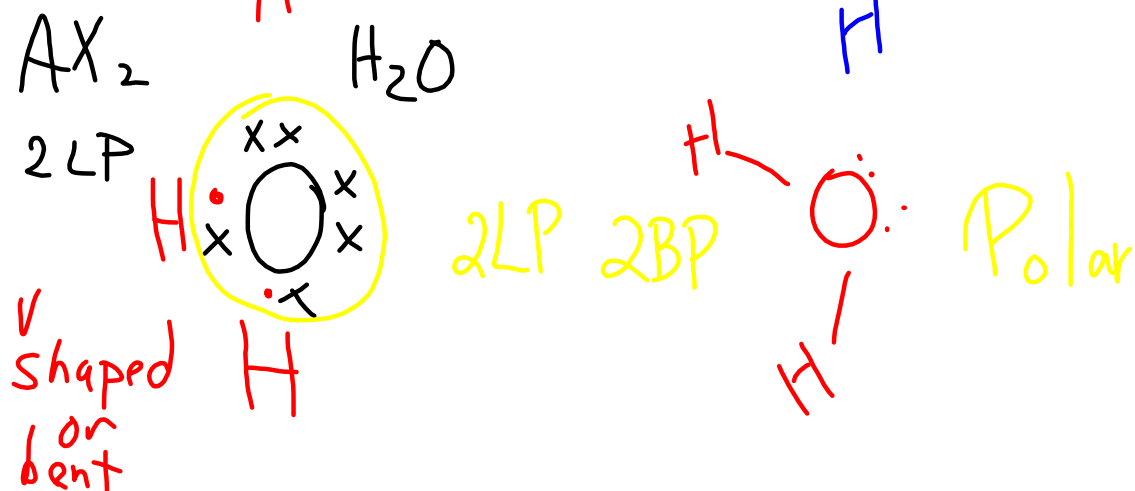
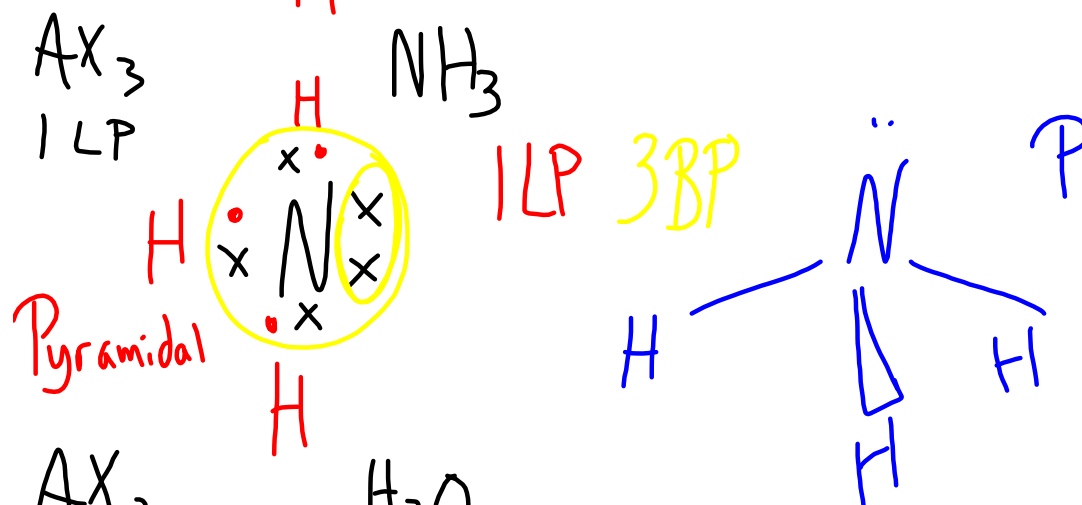
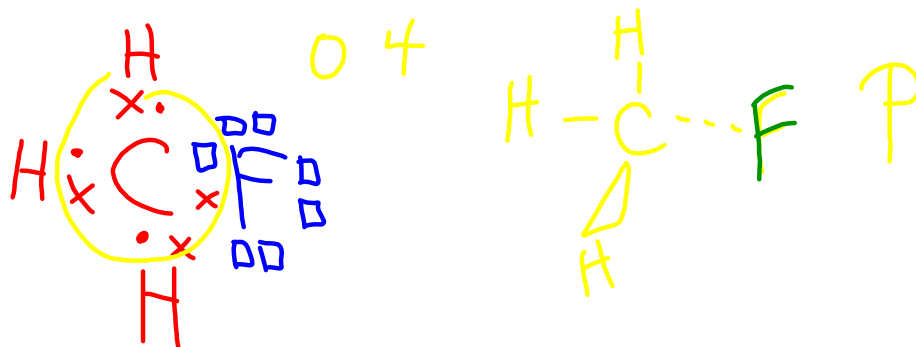
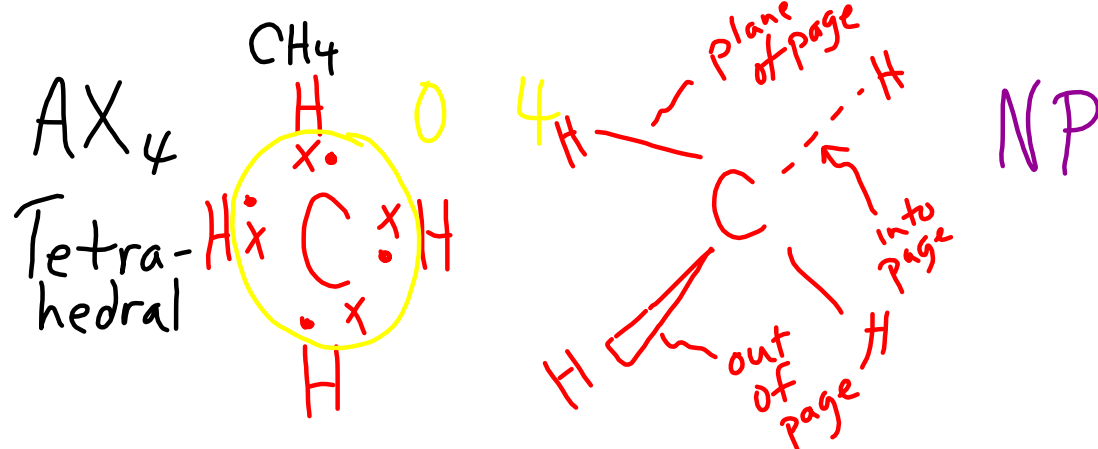
Shape	Lewis	LP	BP	Structure or	Polar
General Formula	Diagram			shape diagram	or Nonpolar



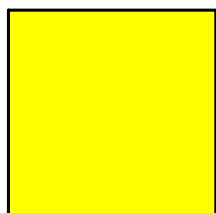
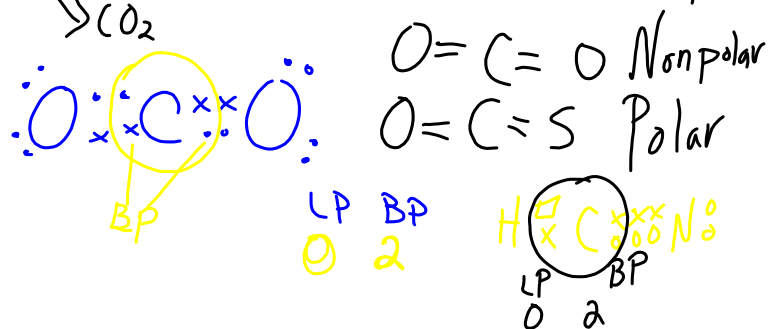
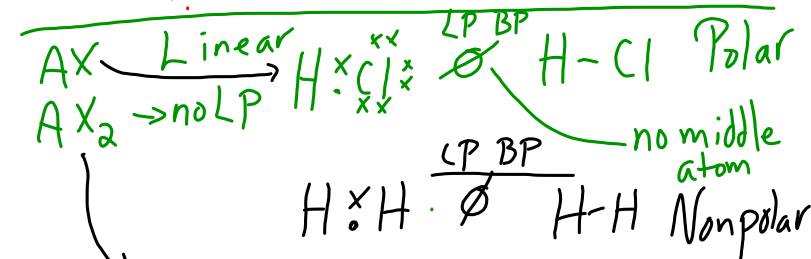
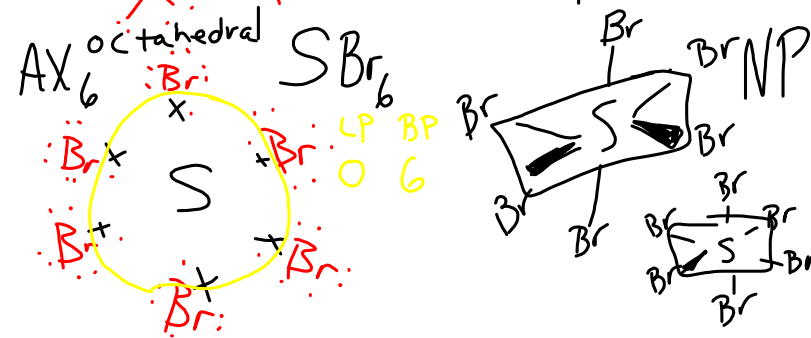
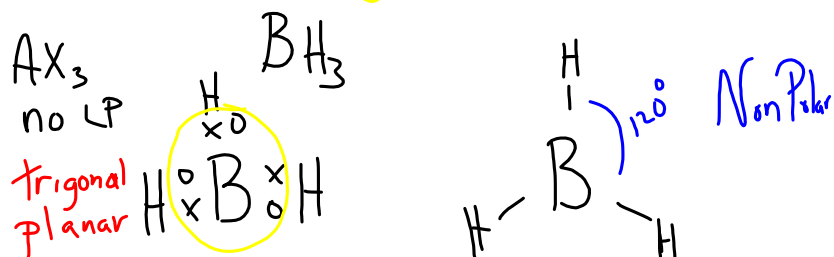


## VSEPR

Shape	Lewis Diagram	LP	BP	Structure or shape diagram	Polar or Nonpolar
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Shape	Lewis Diagram	LP	BP	Structure or shape diagram	Polar or Nonpolar
General Formula and name		0	3		

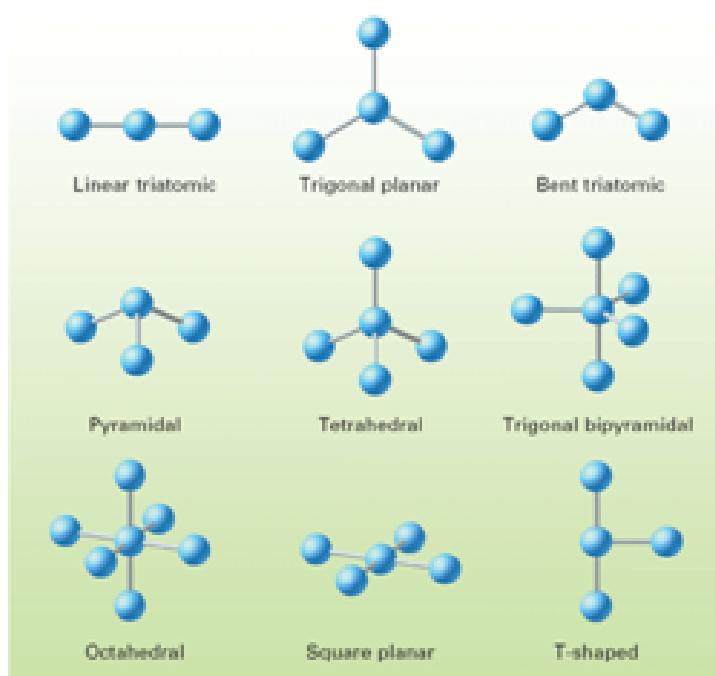


The valence-shell electron-pair repulsion theory or **VSEPR theory**, explains the three-dimensional shape of methane.

## 8.3

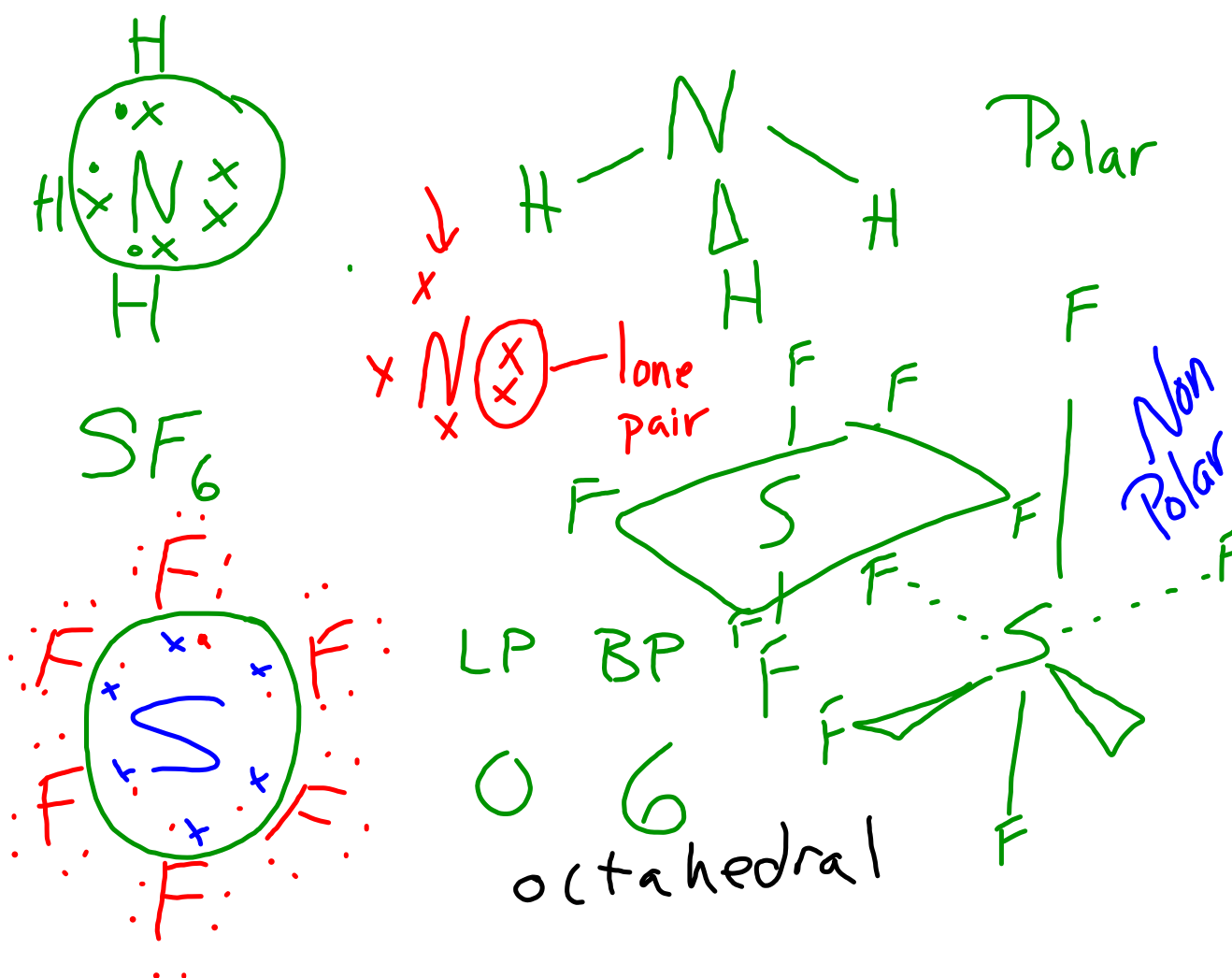
## Bonding Theories &gt; VSEPR Theory

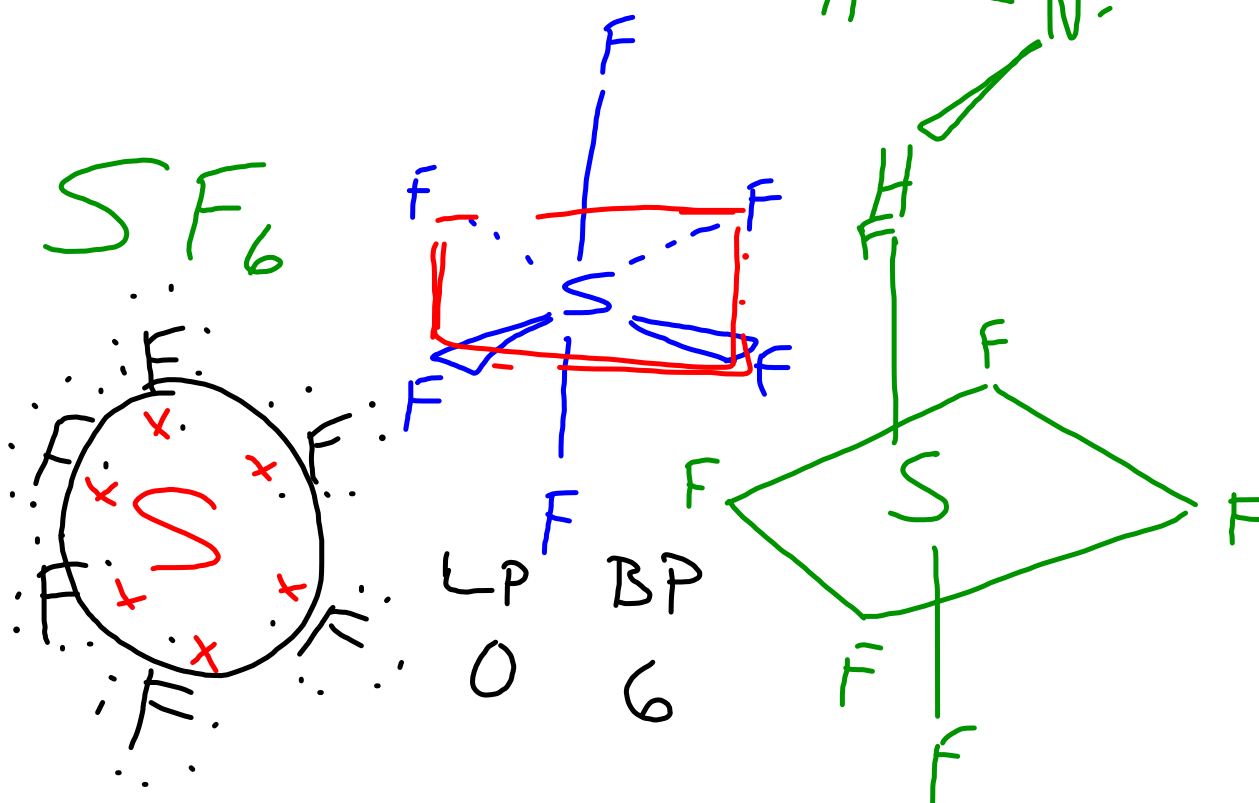
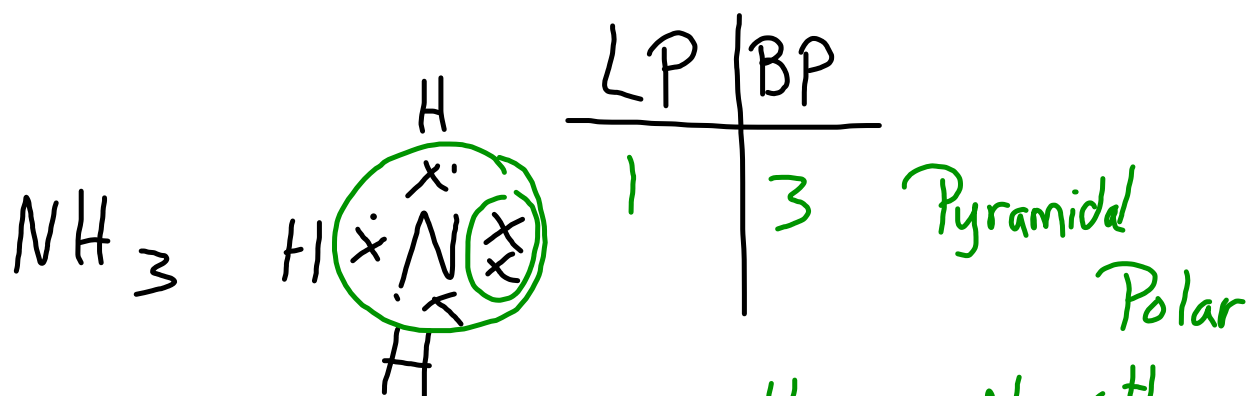
## Nine Possible Molecular Shapes



When a central atom has <sup>\*</sup>no<sup>\*</sup> lone pairs the names of the shapes are:

$AX_2$ $AX$	Linear
$AX_3$	Trigonal planar
$AX_4$	Tetrahedral
$AX_5$	Trigonal bipyramid
$AX_6$	Octahedral





good review

<http://www.youtube.com/watch?v=I2QSCvCT5M8>



Musical

<http://www.youtube.com/watch?v=i3FCHVISZc4>



<http://chemconnections.org/VSEPR/>



<http://winter.group.shef.ac.uk/vsepr/>





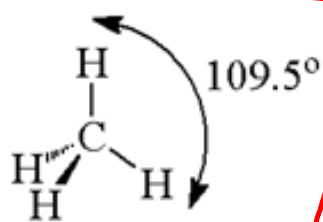
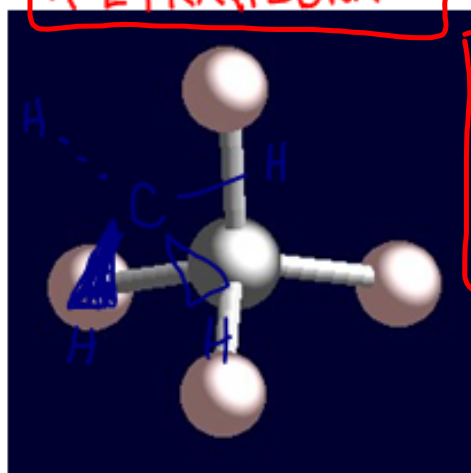
## VSEPR

### Valence Shell Electron Pair Repulsion Theory

AX<sub>4</sub>

R.J Gillespie

TETRAHEDRAL

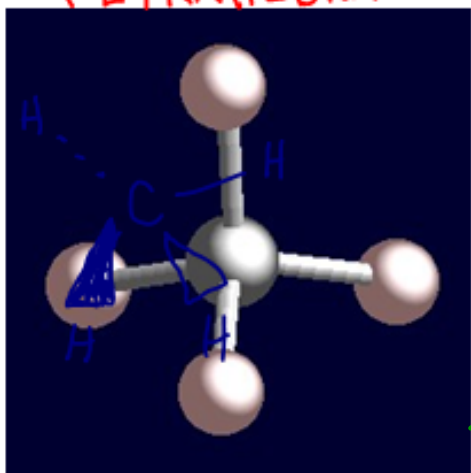


## VSEPR

### Valence Shell Electron Pair Repulsion Theory

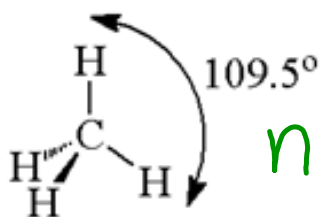
AX<sub>4</sub>

TETRAHEDRAL

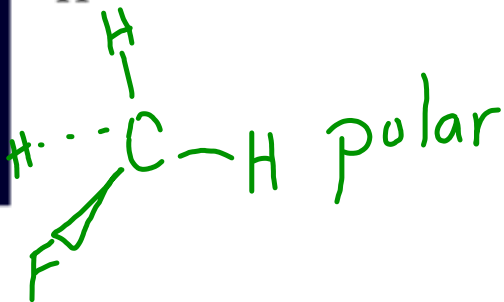


R.J. Gillespie

BP	LP
4	0



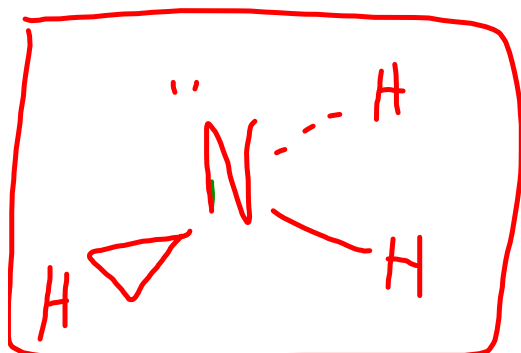
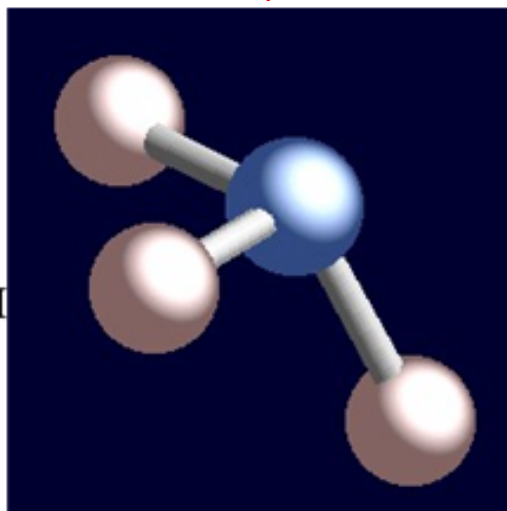
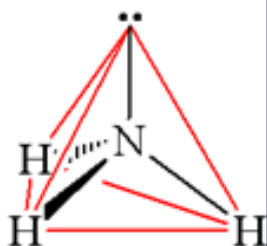
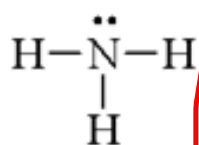
non polar

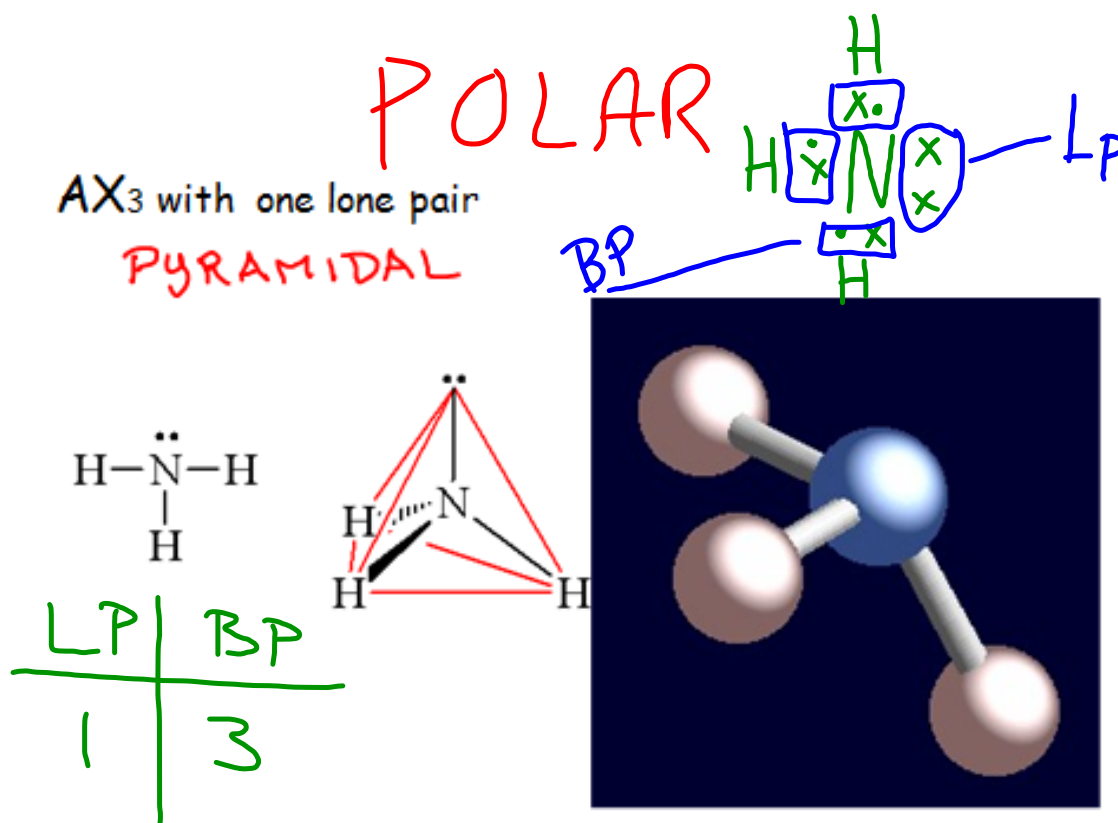


AX<sub>3</sub>E



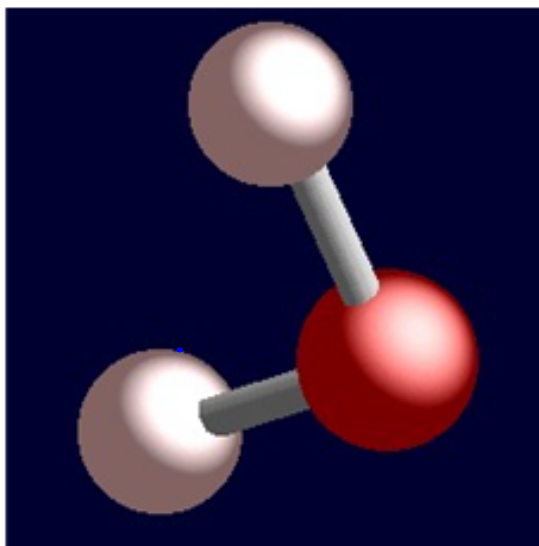
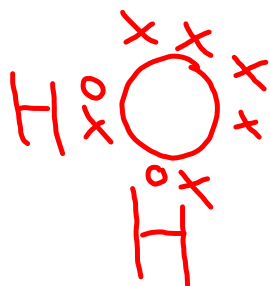
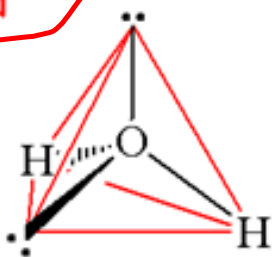
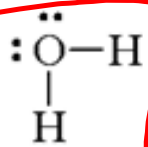
AX<sub>3</sub> with one lone pair  
PYRAMIDAL





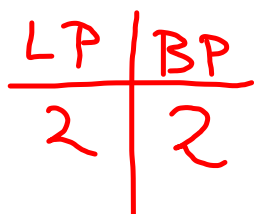
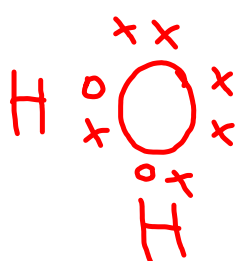
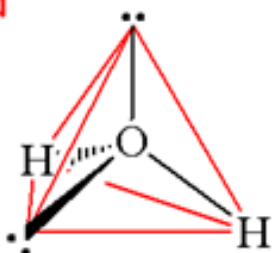
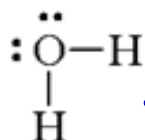
AX<sub>2</sub> with two lone pairs

v shaped  
or bent

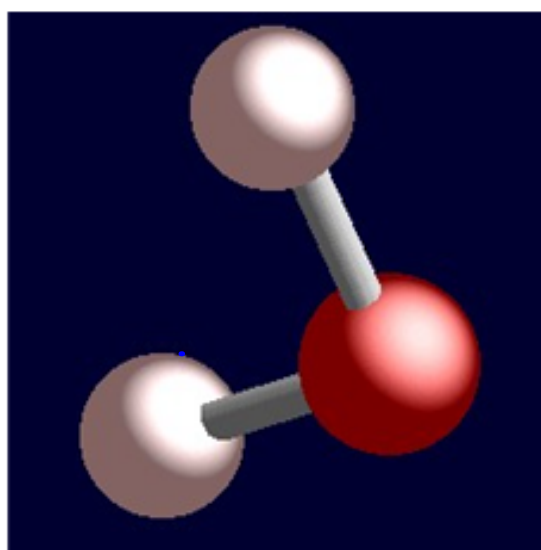


AX<sub>2</sub> with two lone pairs

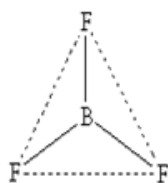
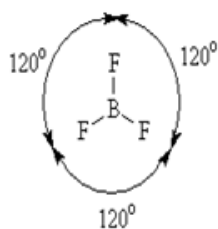
v shaped  
or bent



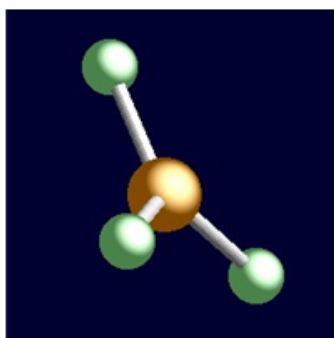
POLAR



$AX_3$  no lone pairs

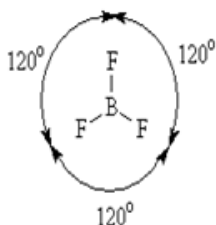


Trigonal  
Planar

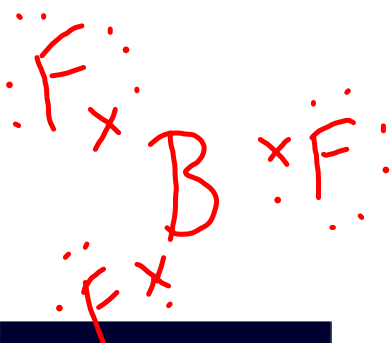
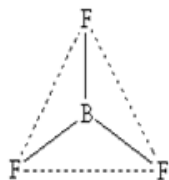




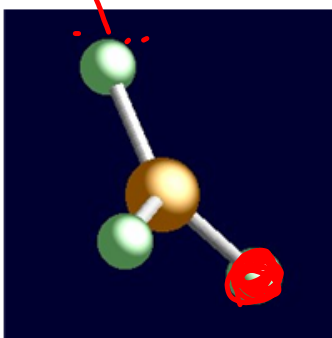
AX<sub>3</sub> no lone pairs



Trigonal  
Planar



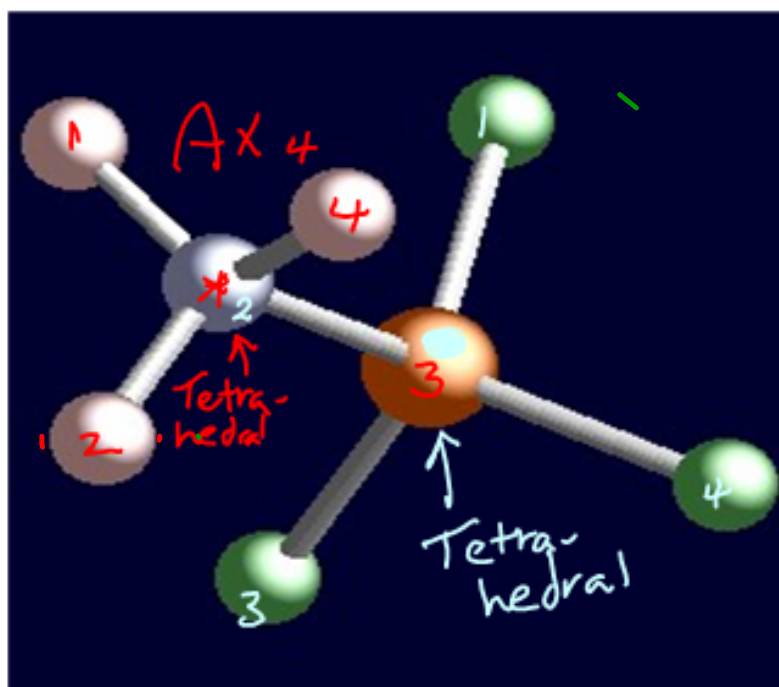
Non-  
Polar



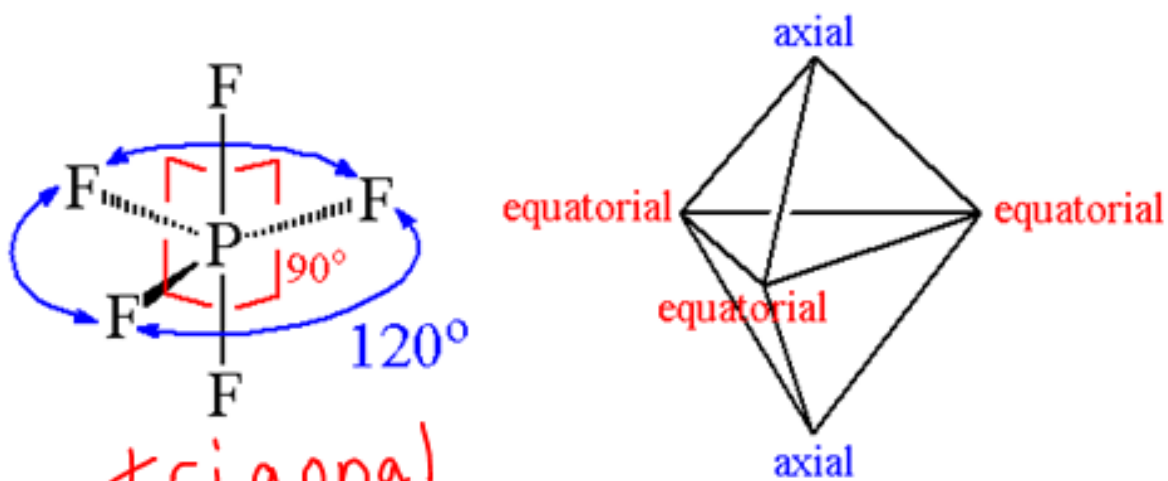
LP	BP
0	3

$\text{BF}_2\text{Cl}$  Polar

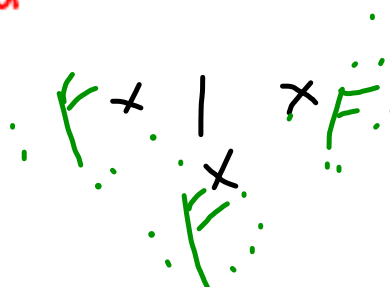
Two AX<sub>4</sub> central atoms with no lone pairs

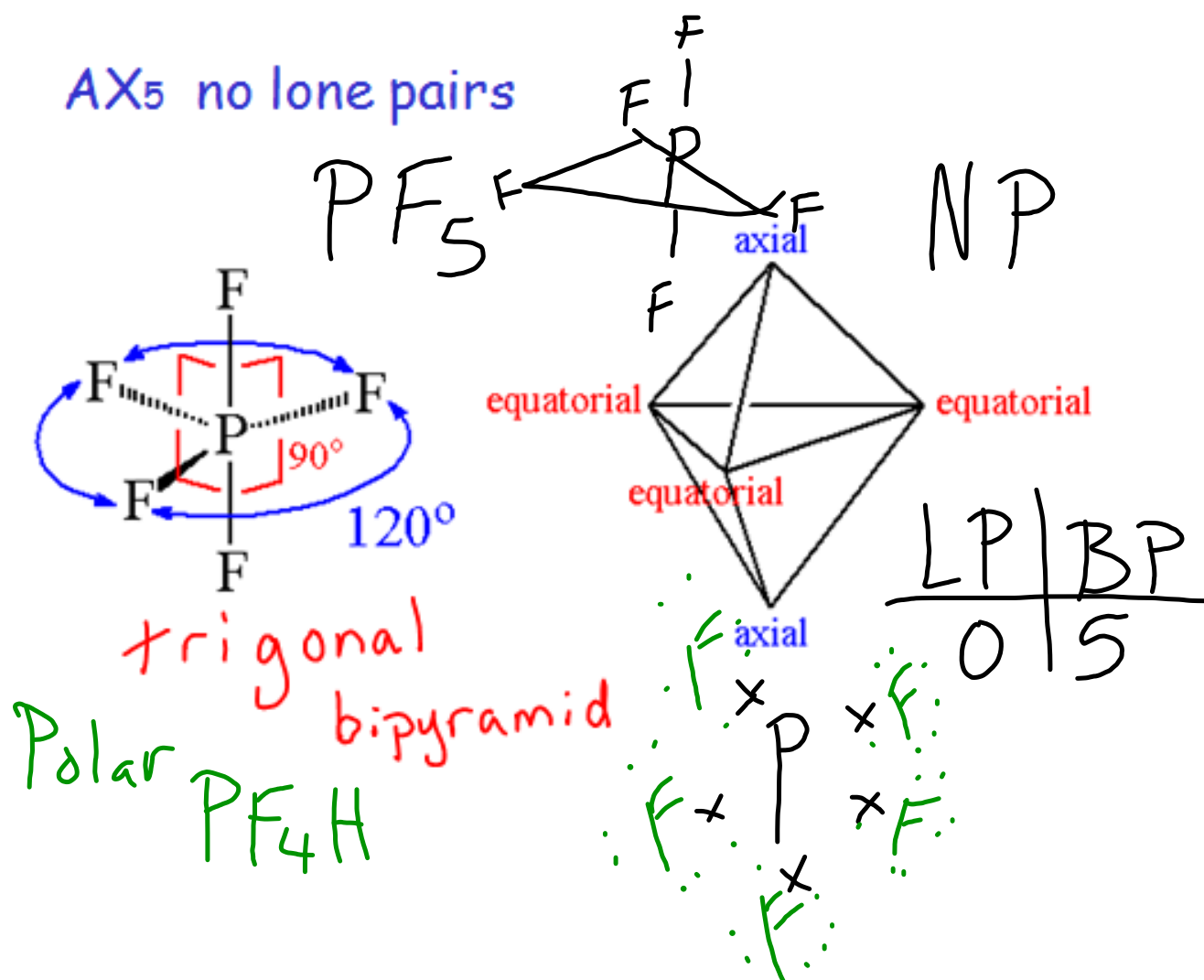


AX<sub>5</sub> no lone pairs



trigonal  
bipyramid



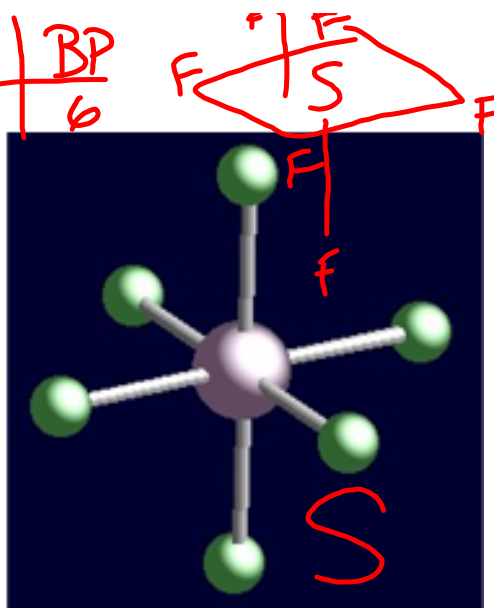
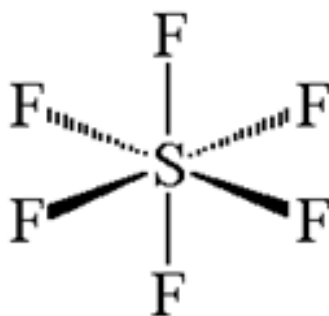


$\text{SF}_5\text{Cl}$  - Polar

$\text{AX}_6$  with no lone pairs

Octahedral

NP

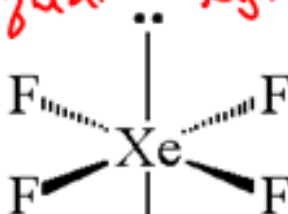


$\text{AX}_5$  with 1 L.P.  $\rightarrow$  Square Pyramidal

Lewis



VSEPR



Square Planar  $\text{AX}_4$  2 l.p.

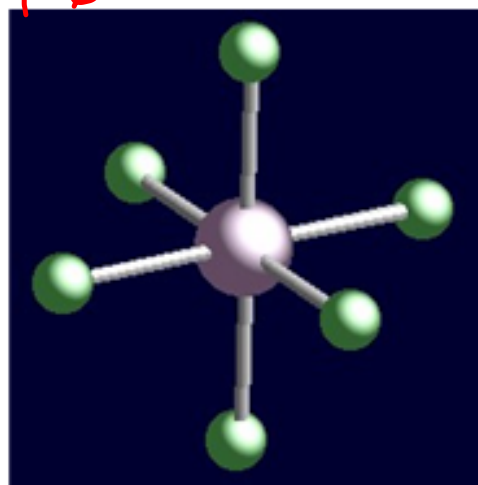
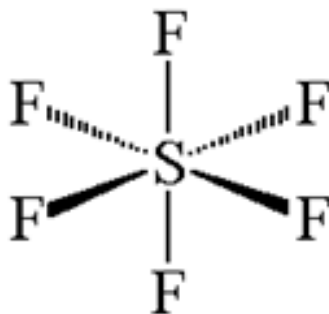
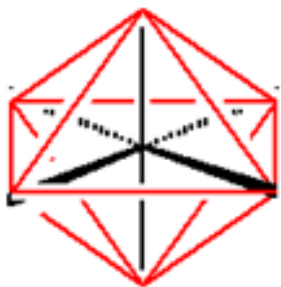


$\text{SF}_5\text{Cl}$  - Polar

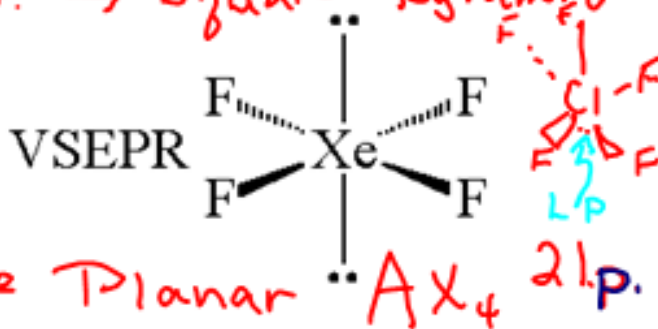
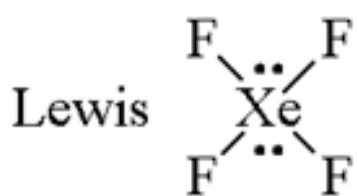
$\frac{\text{LP}}{0} \mid \frac{\text{BP}}{6}$

$\text{AX}_6$  with no lone pairs

Octahedral NP



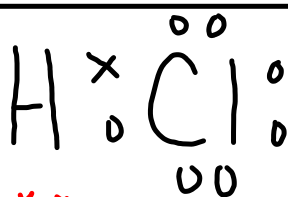
$\text{AX}_5$  with 1 L.P.  $\rightarrow$  Square Pyramidal



$AX_2$  -  $\overset{\text{no}}{\text{LP}}$   
OR  $AX$

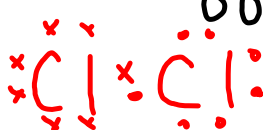
Linear

HCl



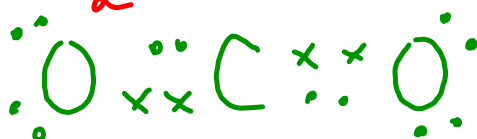
H-Cl

Polar  
non polar



Cl-Cl

$\text{CO}_2$



$\text{O}=\text{C}=\text{O}$

Non-  
polar

When a central atom has <sup>\*</sup>no<sup>\*</sup> lone pairs the names of the shapes are:

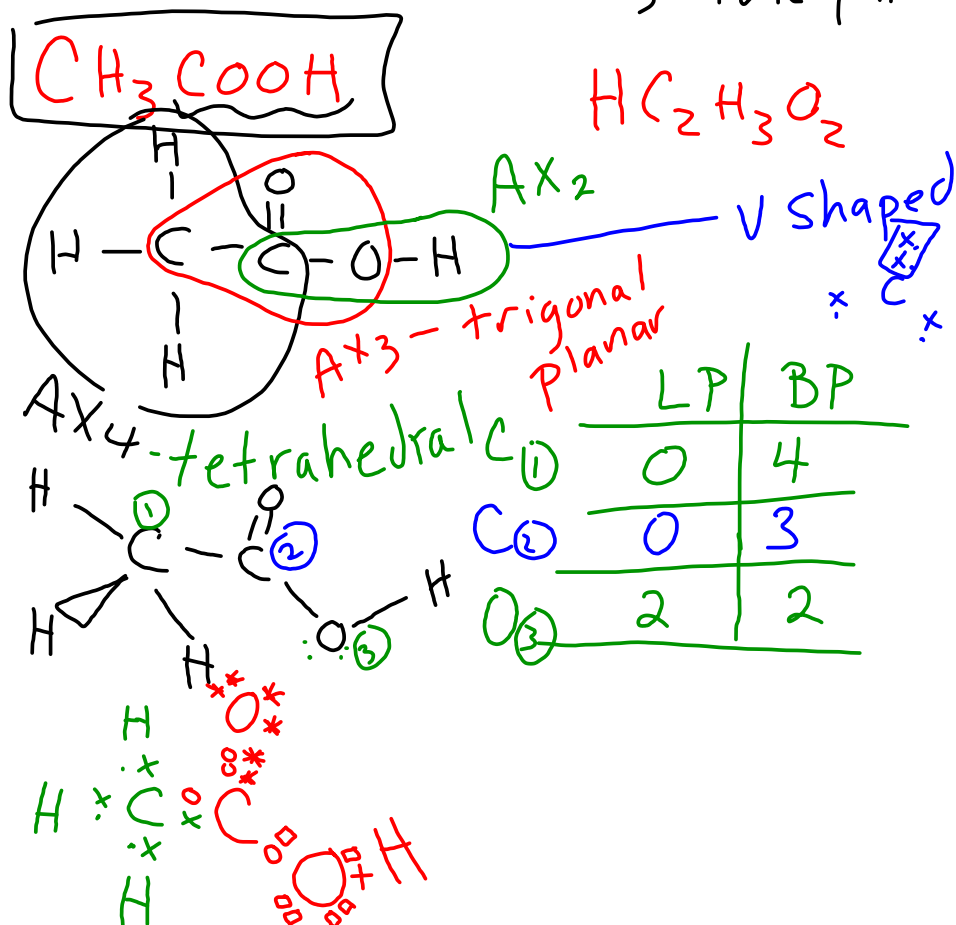
AX <sub>2</sub> AX	Linear
AX <sub>3</sub>	Trigonal planar
AX <sub>4</sub>	Tetrahedral
AX <sub>5</sub>	Trigonal bipyramid
AX <sub>6</sub> SF <sub>6</sub>	Octahedral

AX<sub>2</sub> V shape  $\rightsquigarrow$  lone pairs

or linear  $\rightsquigarrow$  no lone pairs

AX<sub>3</sub> trigonal planar  $\rightarrow$  no lone pairs

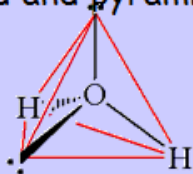
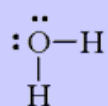
Pyramidal  $\rightarrow$  lone pair





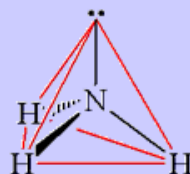
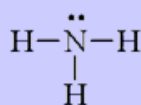
Other possibilities exist  
when there are lone pairs:

Consider water and  
ammonia...they started out  
tetrahedral and became  
v-shaped and pyramidal



V shaped

pyramidal

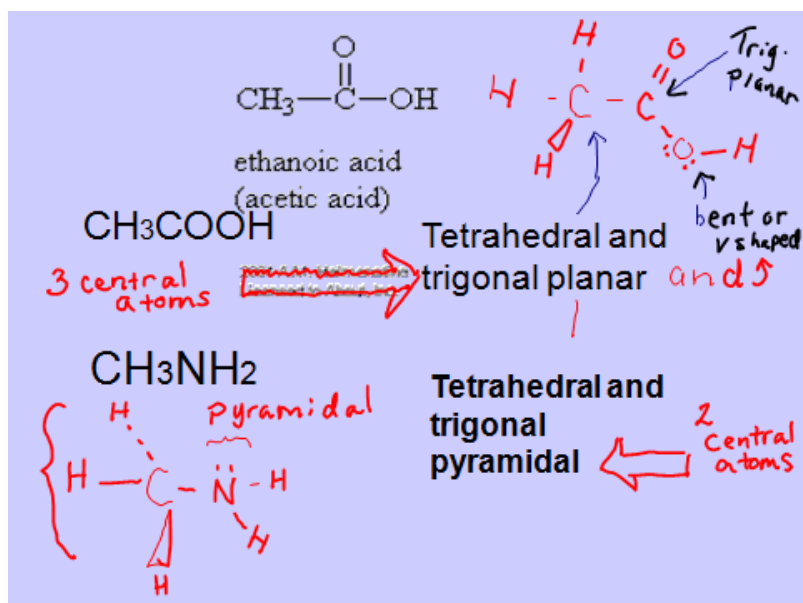


References:

<http://www.shef.ac.uk/~chem/vsepr/>  
(does not work)  
<http://www.stfx.ca/people/dklapste/Chem120/vsepr/VSEPR3.HTML>

Total Number of Atoms + Lone pairs around central atom	Geometry
No Central Atom	Linear $O_2$ $N_2$ $AX$ $O_2$ $N_2$ $AX_2$ $2BP$ $0LP$ $C \equiv O_2$
2 $AX_2$	Linear $CO_2$
3 $AX_3$	Trigonal Planar $BF_3$ $0$ $BP$ $3$ Bent $SO_2$ $H_2O$
4 $AX_4$	Tetrahedral $CH_4$ $LP$ $0$ $BP$ $4$ Trigonal Pyramidal $NH_3$ $AX_3E$ Bent $H_2O$ $AX_2E_2$
5 $AX_5$	Trigonal Bipyramidal $PF_5$ $LP$ $0$ $BP$ $5$ See-saw $SF_4$ $1$ $BP$ $4$ T-Shaped $ClF_3$ $2$ $BP$ $3$ Linear $XeF_2$
6 $AX_6$	Octahedral $SF_6$ $LP$ $0$ $BP$ $6$ Square Pyramidal $BrF_5$ $LP$ $1$ $BP$ $5$ Square Planar $XeF_4$ $LP$ $2$ $BP$ $4$ T-shaped $3$ $BP$ $3$

Linear  
 4 2  
 LP BP





The site below contains an  
review of all shapes and ge

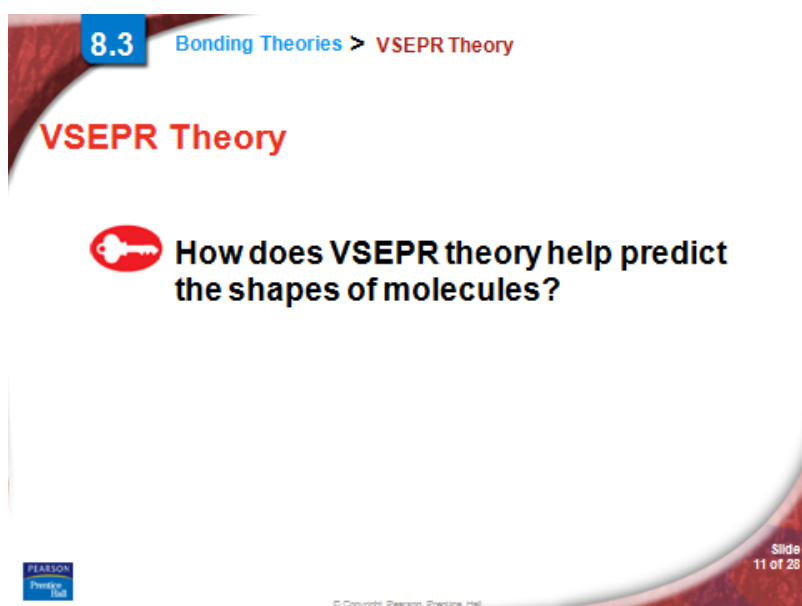
Great review sites:

[http://chemed.chem.purdue.edu/  
review/bp/ch8/table.html](http://chemed.chem.purdue.edu/review/bp/ch8/table.html)

[http://library.thinkquest.org/C006669/data/Chem/bonding/shapes.  
html](http://library.thinkquest.org/C006669/data/Chem/bonding/shapes.html)


<http://winter.group.shef.ac.uk/vsepr/geometries.html>

<http://mc2.cchem.berkeley.edu/VSEPR>  
<http://www.chemistry-drills.com/VSEPR.php>



8.3 Bonding Theories > VSEPR Theory

## VSEPR Theory

 How does VSEPR theory help predict the shapes of molecules?

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This slide is part of a presentation on VSEPR Theory. It features a red and white curved border on the left and bottom. The title 'VSEPR Theory' is in red. A key icon is next to the main question. The Pearson Prentice Hall logo is in the bottom left, and the slide number 'Slide 11 of 28' is in the bottom right.

the hydrogens in a methane molecule are at the four corners of a geometric solid. All of the  $\text{C-H}$  angles are  $109.5^\circ$ , the tetrahedral angle.

8.3

Bonding Theories &gt; VSEPR Theory

8.3

Bonding Theories &gt; VSEPR Theory

angle in water is about

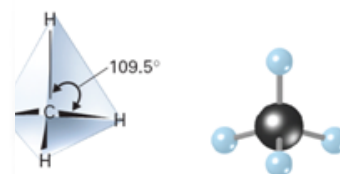
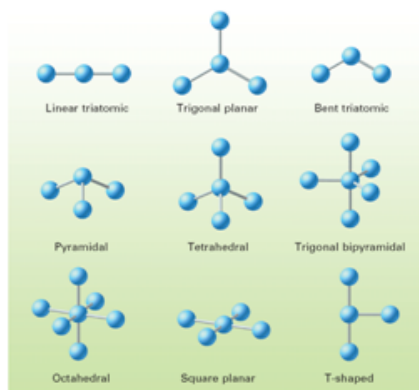
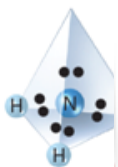
8.3

Bo

### Nine Possible Molecular Shapes

The cart

Ammonia ( $\text{NH}_3$ )



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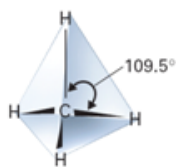
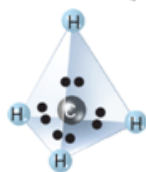


## 8.3

## Bonding Theories &gt; VSEPR Theory


The measured bond angle in water is about  $105^\circ$  .

Methane ( $\text{CH}_4$ )



The valence-shell electron-pair repulsion theory, or **VSEPR theory**, explains the three-dimensional shape of methane.

**8.3** Bonding Theories > VSEPR Theory

 According to VSEPR theory, the repulsion between electron pairs causes molecular shapes to adjust so that the valence-electron pairs stay as far apart as possible.

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## 8.3

Bonding Theories &gt; Molecular Orbital

**Sigma Bonds**

When two atomic orbitals combine to form a bonding molecular orbital that is symmetric about the axis connecting two atomic nuclei, a **sigma bond** is formed.



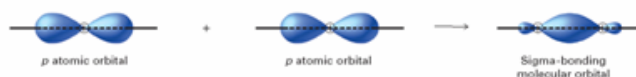
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## 8.3

Bonding Theories &gt; Molecular Orbitals

When two fluorine atoms combine, the *p* orbitals overlap to produce a bonding molecular orbital. The F—F bond is a sigma bond.

⊕ represents the nucleus.

*p* atomic orbital*p* atomic orbital

Sigma-bonding molecular orbital

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**8.3** Bonding Theories > Molecular Orbital

### Pi Bonds

In a **pi bond** (symbolized by  $\pi$ ), the bonding electrons are located in sausage-shaped regions above and below the bond axis of the bonded atoms.

**8.3** Bonding Theories > Molecular Orbitals

### Pi-bonding Molecular Orbital

$\oplus$  represents the nucleus.

$p$  atomic orbital       $p$  atomic orbital      Pi-bonding molecular orbital

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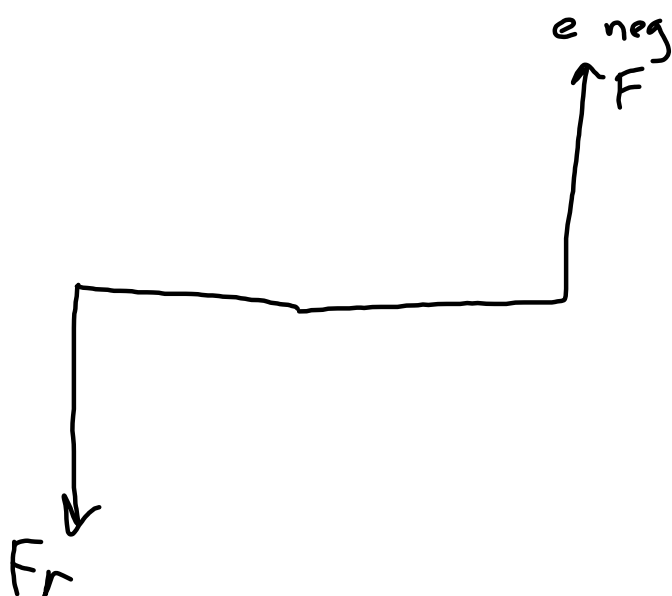
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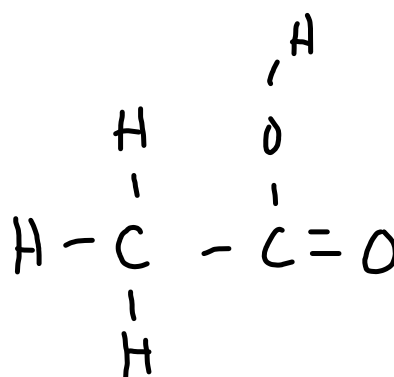
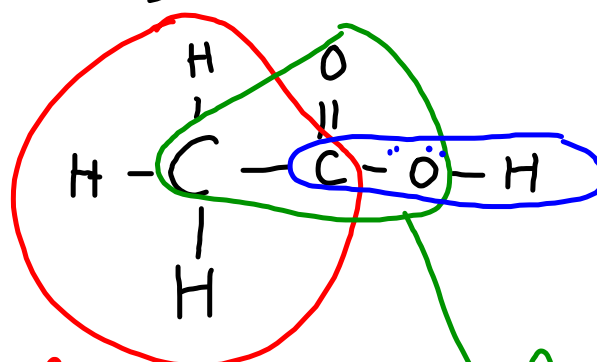
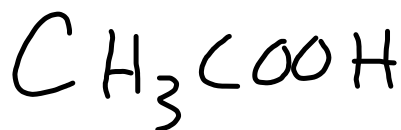
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Formula	Lewis Diagram	Shape	Shape with bond dipoles	Polarity LP BP
$N_2$	$\text{:}\overset{\times}{\underset{\times}{N}}\text{---}\overset{\times}{\underset{\times}{N}}\text{:}$ AX	Linear	$N\equiv N$ $\leftarrow \rightarrow$	Non-polar N/A 1
$HBr$	$H\overset{\times}{\underset{\times}{:}}\overset{\times}{\underset{\times}{Br}}\text{:}$ AX	Linear	$H-\overset{\oplus}{Br}{}^{\ominus}$ $\rightarrow$	Polar N/A 1
$OCl_2$	$\begin{array}{c} \times \times \\ \times O \times \times \\ \times \times \end{array} \begin{array}{c} \times \times \\ \times Cl \times \times \\ \times \times \end{array}$ $\begin{array}{c} \times \times \\ \times Cl \times \times \\ \times \times \end{array}$	VShaped	$\begin{array}{c} \leftarrow \\ O-Cl \\ \uparrow \\ Cl \end{array}$	Polar 2 2

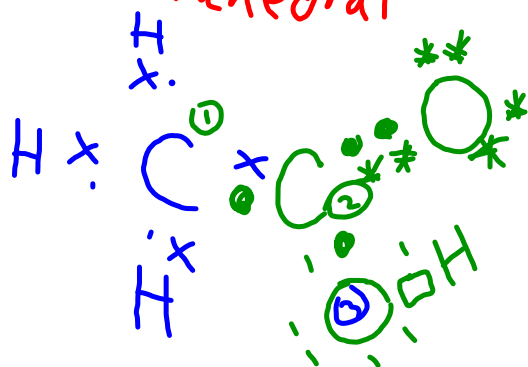




$\text{AX}_2$   
bent or  
V shaped

$\text{AX}_4$

tetrahedral



$\text{AX}_3$   
Trigonal  
planar

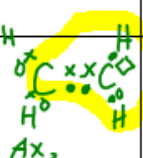
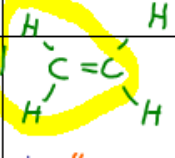
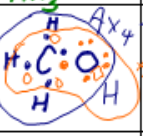
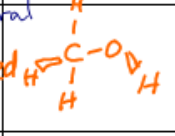
	LP	BP
$\text{C}_1$	0	4
$\text{C}_2$	0	3
$\text{O}_1$	2	2

$\text{AX}_2$  Linear no lone pair  
V shaped has lone pairs

$\text{AX}_3$  trigonal planar no lone pair  
pyramidal has a lone pair

Formula	Lewis Diagram	Shape	Shape with bond dipoles	Polarity	LP	BP
$\text{SiCl}_4$ $\text{AX}_4$		Tetra- hedral		Non Polar	0	4
$\text{CHI}_3$ $\text{AX}_4$		Tetra- hedral		Polar	0	4
$\text{C}_2\text{H}_3\text{Cl}$ $\text{AX}_3$		$\text{AX}_3$ Trigonal Planar		Polar	0	3



Formula	Lewis Diagram	Shape	Shape with bond dipoles	Polarity
7 $C_2H_4$		Trigonal Planar $AX_3$		Non Polar
8 $CH_3OH$		Tetrahedral $AX_4$ $AX_2 \rightarrow$ V shaped		Polar

Formula	Lewis Diagram	Shape	Shape with bond dipoles	Polarity

	Formula	Lewis Diagram	Shape	Shape with bond dipoles	Polarity
8	$C_2I_2Br_2$	<p>#LP #BP  <math>Ax_2</math></p>	<p>2 2</p>	<p><math>Ax_2</math></p>	Polar
13	$N_2H_3F$	<p>#LP #BP          (1) 1 3          (2) 1 3  <math>Ax_3</math></p>		<p><math>Ax_3</math></p>	Polar
		<p><math>Ax_3</math></p>			

Formula	Lewis Diagram	Shape	Shape with bond dipoles	Polarity
TRY THESE: LP BP				
$\text{OF}_6$				
$\text{PF}_4\text{Cl}$				



Molec- ular formula	Lewis electron dot diagram	# of lone pairs	# of bond- ing pairs	Name of shape	Polarity And struct- ural dia-- gram
$AX$ $AX_2$				Linear	
$AX_3$				Trigonal Planar Trigonal Pyramid	

$AX_4$  Tetrahedral

$AX_5$  Trigonal Bipyramid

$AX_4$  with 1 Lone pair See saw

$AX_6$  Octahedral

Total Number of Atoms + Lone pairs around central atom	Geometry			
No Central Atom	Linear $O_2$ $N_2$	With Lone Pairs $O_2$ $N_2$		
2	Linear $CO_2$			
3	Trigonal Planar $BF_3$	Bent $SO_2$		
4	Tetrahedral $CH_4$	Pyramidal $NH_3$	Bent $H_2O$	
5	Trigonal Bipyramidal $PF_5$	See-saw $SF_4$	T-Shaped $ClF_3$	Linear $XeF_2$
6	Octahedral $SF_6$	Square Pyramidal $BrF_5$	Square Planar $XeF_4$	

Total Number of Atoms + Lone pairs around central atom	Geometry			
No Central Atom	Linear $O_2$ $N_2$	With Lone Pairs $O_2$ $N_2$		
2	Linear $CO_2$			
3	Trigonal Planar $BF_3$	Bent $SO_2$		
4	Tetrahedral $CH_4$	Pyramidal $NH_3$	Bent $H_2O$	
5	Trigonal Bipyramidal $PF_5$	See-saw $SF_4$	T-Shaped $ClF_3$	Linear $XeF_2$
6	Octahedral $SF_6$	Square Pyramidal $BrF_5$	Square Planar $XeF_4$	

